

Nonlocal thermodynamic equilibrium

SPECTRAL LINE FORMATION. By John T. Jefferies. 298 pp. Blaisdell, Waltham, Mass., 1968. \$10.50

by DONALD E. BLACKWELL

Since the beginning of astrophysics in the mid nineteenth century, spectroscopy has been one of the astronomer's chief tools. On the experimental and observational sides, the subject has advanced very rapidly, and a great abundance of fascinating new data has been derived from the use of fine new large gratings and new spectroscopic techniques with large telescopes. There have also been considerable advances since the war in the theoretical interpretation of atomic spectra, although here progress has been steady rather than spectacular.

However, somewhat surprisingly, the theory of the formation of spectral lines in stellar atmospheres is still in a comparatively rudimentary state. During the first quarter of this century astronomers thought of spectral-line formation as analogous to the formation of the absorption line of sodium in the famous Kirchhoff experiment, in which continuous radiation from a high-temperature source is passed

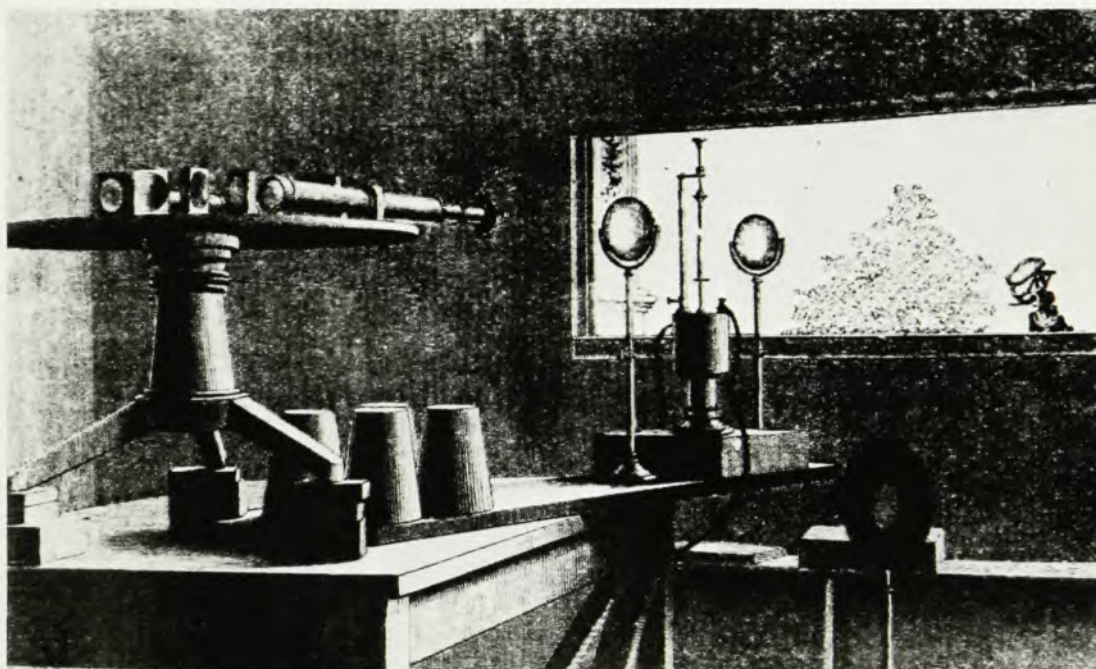
through cooler sodium vapor. This idea led to the concept of a stellar "reversing layer" (in which absorption lines are formed), which overlies a hotter region that is responsible for the continuous background. We now know that this picture is quite inadequate, and that line absorption and continuous emission are both taking place in the same regions of the atmosphere.

This later view has stimulated a large body of work to interpret observations of absorption lines, partly on the calculation of continuous absorption coefficients and partly on the measurement of oscillator strengths, or atomic transition probabilities. However, in applying this theory almost all investigations have presupposed a state of local thermodynamic equilibrium in the atmosphere, an assumption that implies that the relative populations of energy levels of atoms can be calculated from the Boltzmann law using the local value of temperature. Also, except in very exceptional circumstances, investigators have supposed that absorption lines are formed only by the mechanism of pure absorption, and they have neglected scattering processes.

John Jefferies in *Spectral Line Formation* has consistently maintained that this simple approach to spectral-line formation is very far from adequate, and indeed there is often clear disagreement with the observational results. In his book he takes the reader through the more sophisticated nonlocal thermodynamic equilibrium theories that he and his chief colleagues, Richard Thomas and Grant Athay, have developed in papers published during the last two decades. It is a pleasure to see the gist of these papers presented in an attractive, lucid and connected form, and in such a way as to be of use to astrophysicists concerned with spectral-line formation and to all laboratory spectroscopists. The author's aim has been to present a complete text, and the early chapters describe fairly well known and conventional aspects of atomic theory, such as pressure broadening, the line-absorption coefficient and the continuous-absorption coefficient.

The later chapters describe Jefferies's own techniques, which he illustrates in detail by their application to a two-level atom and later, in outline, to a multilevel atom. There is a particularly interesting reference to

APPARATUS used by Sir Norman Lockyer in the mid-19th century to determine coincidences of solar and metallic lines. (Engraving is from Lockyer's *Chemistry of the Sun*, reproduced in *Astronomy*, by Fred Hoyle.)



the *H* and *K* lines of singly ionized calcium, in which a simple and natural explanation is offered for their remarkable profiles. The book concludes with a clearly reasoned survey of the evidence for and against the supposition of local thermodynamic equilibrium in the solar atmosphere. This is an important question because practically all work on relative abundances assumes a local thermodynamic equilibrium, and also because of the present discrepancy between the supposed photospheric and coronal abundances of iron, which are not at all understood. In all, a timely book on a topic that is scarcely touched upon in any other work.

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D. E. Blackwell is with the astrophysics department at the Oxford University Observatory.

All-purpose introductory texts

FOUNDATIONS OF PHYSICS. By Walter C. Michels, Malcolm Correll and A. L. Patterson. 886 pp. D. Van Nostrand, Princeton, N. J., 1968. \$12.95

A CONTEMPORARY VIEW OF ELEMENTARY PHYSICS. By Sidney Borowitz and Lawrence A. Bornstein. 896 pp. McGraw-Hill, New York, 1968. \$12.00

by KENNETH W. FORD

No textbook can be properly reviewed until it has been used. I have made many misjudgments about a book and later had to revise my opinion, upward or downward, after classroom experience. Here, then, is a pair of improper reviews, offered without classroom experience.

W. C. Michels, M. Correll, and A. L. Patterson's *Foundations of Physics* and S. Borowitz and L. A. Bornstein's *A Contemporary View of Elementary Physics* are very different books; yet they have, besides their 900-page bulk, a number of things in common. Both intend to be all-purpose introductory books, suitable for both physics majors and nonmajors. Both sets of authors believe, rightly I think, that we usually make too much of the difference between majors and nonmajors. Accordingly they emphasize that physics is much more than sets of equations and recipes for solving problems, and both hold mathematics to a modest level.

Foundations . . . uses calculus, *A Contemporary View . . .* does not; yet this difference is more illusory than real. In the former, the calculus is sparse, and many topics are treated qualitatively: The latter makes fairly free use of Δ 's, and includes solid angle and some Fourier analysis. I would consider Borowitz and Bornstein's book slightly more demanding mathematically, although certainly either book could be used in a "non-

calculus" course. Both books avoid a historical approach, but my impression is that the history in *Foundations . . .* is more reliable.

Among these five authors is a great deal of experience in elementary-physics teaching; their keen interest in pedagogy shows clearly in both books. Unfortunately neither book can be awarded a gold star for prose style, and I would rate them about the same in this respect. The writing is adequate; neither inspiring nor annoying. But both books are well organized and have many good figures and an excellent index.

Now to some significant differences. *A Contemporary View . . .* is considerably the more unconventional. It

is organized into just four big blocks: mechanics, thermodynamics, waves and the structure of matter. The Lorentz transformation appears on page 31, and relativity is used throughout with electromagnetism dispersed in pieces. It is decidedly theoretical, with fairly deep treatments of thermodynamics and oscillatory motion, but is, on the other hand, almost entirely devoid of practicalities. I could find neither a single circuit diagram, nor any mention of transistors, diodes, triodes, microscopes, telescopes, dewars, or Wheatstone bridges, to mention some devices that are described in *Foundations . . .*. Indicative of his theoretical emphasis is the absence of any photographs, except on title pages.

Foundations . . ., with more and shorter chapters, is organized roughly into nine blocks: mechanics (including relativity), heat, waves and optics, gravity, electromagnetism, the structure of matter, kinetic theory, oscillation and electromagnetic waves, and quantum mechanics and atomic structure. This organization, although somewhat unconventional, is not radical. Numerous photographs and good figures supplement the text. The practical and the theoretical stand in good balance and many references are provided at the ends of the chap-

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